Small Business Innovation Research/Small Business Tech Transfer

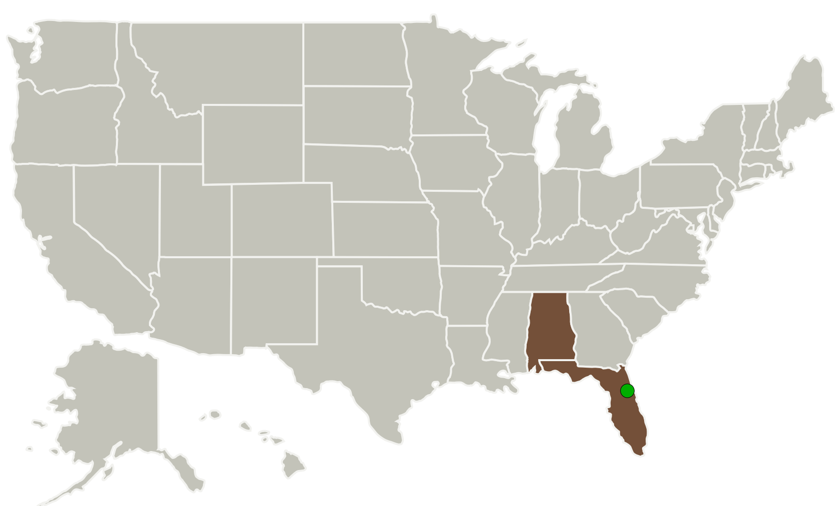
Particle Flow Physics Modeling for Extreme Environments, Phase I

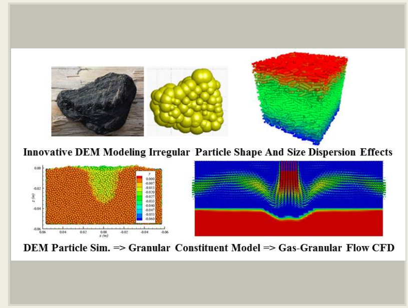
Completed Technology Project (2013 - 2014)

Project Introduction

The liberation of particles induced by rocket plume flow from spacecraft landing on unprepared regolith of the Moon, Mars, and other destinations poses high mission risks for robotic and human exploration activities. This process occurs in a combination of "extreme environments" that combine low gravity, little or no atmosphere, with rocket exhaust gas flow that is supersonic and partially rarefied, and unusual geological and mechanical properties of highly irregular soil regolith. CFDRC and the University of Florida have previously developed unique plume driven erosion simulation software for such environments by combining novel granular physics simulation modules developed by UF with the Unified Flow Solver (UFS) plume flow simulation software developed by CFDRC. Granular flow constitutive models, formulated through first-principle 3-D Discrete Element Method particle kinetics simulations, were implemented for efficient Eulerian gas-granular flow CFD modeling in the UFS simulation framework. Resultant simulations realistically capture the granular flow characteristics of particle erosion and cratering scenarios. The goal of this project is to dramatically advance the fidelity of these simulations towards simulating actual extra-terrestrial soil compositions with broad shape and size variations. This will be achieved through applying recent, novel particle kinetics modeling concepts to formulate granular flow physics models for both, realistic irregular particle shapes and realistically dispersed particle size distributions. The proposed technology development will result in unprecedented computer modeling capability for predicting liberation and flow of realistic granular material compositions in extreme extra-terrestrial environments.

Primary U.S. Work Locations and Key Partners





Particle Flow Physics Modeling for Extreme Environments

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Organizations Performing Work	Role	Type	Location
CFD Research Corporation	Lead Organization	Industry	Huntsville, Alabama
Kennedy Space Center(KSC)	Supporting Organization	NASA Center	Kennedy Space Center, Florida
University of Florida	Supporting Organization	Academia	Gainesville, Florida

Primary U.S. Work Locations	
Alabama	Florida

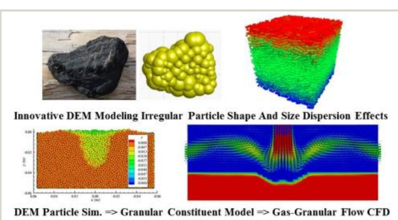
Project Transitions

May 2013: Project Start

May 2014: Closed out

Closeout Documentation:
- Final Summary Chart*(https://techport.nasa.gov/file/140484)*

Images



Project Image
Particle Flow Physics Modeling for Extreme Environments
(https://techport.nasa.gov/image/130500)

Organizational Responsibility

Responsible Mission Directorate:
Space Technology Mission Directorate (STMD)

Lead Organization:
CFD Research Corporation

Responsible Program:
Small Business Innovation Research/Small Business Tech Transfer

Project Management

Program Director:
Jason L Kessler

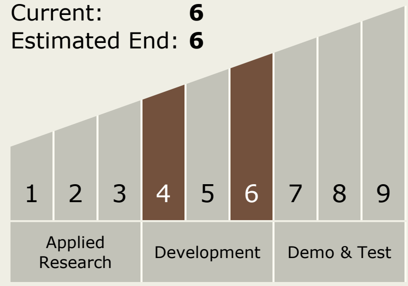
Program Manager:
Carlos Torrez

Principal Investigator:
Peter Liever

Co-Investigator:
Peter Liever

Technology Maturity (TRL)

Start: **4**
Current: **6**
Estimated End: **6**



Technology Areas

Primary:

- TX09 Entry, Descent, and Landing
  - └ TX09.4 Vehicle Systems
    - └ TX09.4.5 Modeling and Simulation for EDL

Target Destinations

The Moon, Mars, Outside the Solar System, The Sun, Earth, Others Inside the Solar System